

PROF. HUXLEY'S LECTURES ON THE EVIDENCE AS TO THE ORIGIN OF EXISTING VERTEBRATE ANIMALS¹

III.

IT will be necessary to preface our remarks as to the origin of the next highest group of Vertebrates—that of Reptiles—by some account of the distinction between them and the Amphibia, and by some observations on what zoologists mean by the terms “higher” and “lower” as applied to animals or groups of animals.

In external form there is little difference between such a reptile as a lizard, and such an amphibian as a newt, and there seems, at first sight, to be no reason why they should be placed in different primary groups. In former times, as a matter of fact, the essential difference between reptiles and amphibians was not seen, and the two were united into a single class; but modern researches have shown that, beneath this external similarity, lie great and important differences, the chief of which we must now consider.

In the first place, no reptile, at any period of its life, possesses gills, and, in consequence, the breathing of air dissolved in water becomes impossible. Nevertheless, reptiles, in common with all the higher animals, have, at one period in their existence, slits leading from the throat to the exterior, in precisely the same position as the branchial clefts of an amphibian, but functionless.

Secondly, certain organs, known as “foetal appendages,” are developed in connection with the young animal before it leaves the egg, and serve a temporary purpose in its economy. In the possession of these appendages, as well as in the absence of gills, reptiles agree with birds and mammals, and differ from fishes and amphibians.

The young reptile is produced from an egg of relatively large size, and consisting of a considerable mass of yolk, surrounded by a quantity of transparent “white” or albumen; the whole being invested by a hard or soft shell. The yolk does not divide as a whole, but the process of division is confined to a small patch on its surface; in fact, the reptilian egg answers to the amphibian egg, *plus* a quantity of additional matter, called accessory, or food-yolk, which is unaffected by the process of yolk-division. It is the small superficial patch, answering to the whole amphibian egg, which is converted into the body of the young reptile, the accessory yolk becoming gradually smaller and smaller, as its substance is used up in the nourishment of the embryo; in the meantime it forms a bag attached to the umbilicus of the embryo, and hence called the *umbilical vesicle* or yolk-sac; it is the first of the foetal appendages, and the only one which occurs in any vertebrate below a reptile, being possessed by certain fishes.

After the embryo has attained a certain size, and has come to lie, like an inverted boat, on the yolk-sac, a fold grows up, all round it, from the surface of the yolk, and, the edges of the fold coming together above, a bag is formed enclosing the embryo into the interior of which a watery fluid is secreted, in which the little creature lies. This natural water-bed is called the *amnion*; it is the second of the foetal appendages, and no trace of it is to be found in any fish or amphibian.

The third and last of these curious embryonic appendages, the *allantois*, grows out from the tail-end of the embryo as a pear-shaped body, solid at first, but soon converted into a sac, which extends round the embryo and yolk-sac, immediately beneath the membrane of the shell. The cavity of the allantois acts as a receptacle for the nitrogenous waste of the embryonic body, but its chief function is as a respiratory organ; for this purpose it is supplied by blood-vessels which form a close network

over its outer layer, and the blood contained in these coming into close relation with the external air, through the porous shell, readily exchanges its carbonic acid for the atmospheric oxygen.

As the embryo grows, the yolk-sac becomes smaller and smaller, and is eventually completely drawn into the interior of the body of the young reptile, which by this time completely fills the shell. In many cases a horny knob is developed on the nose, and, with this, the now ripe embryo breaks the shell from the interior; the amnion and other membranes are burst, the allantoic circulation is stopped, the first inspiration is taken, and the little creature is born.

There are several minor points in which reptiles are distinguished from amphibians, amongst which we will only mention the articulation of the skull to the first vertebra by one condyle instead of two, the presence of a bone called the *basi-occipital* in the hinder part of the skull floor, and the fact that the branchial apparatus is reduced in the adult to the small *hyoid* bone or cartilage, which supports the tongue.

In what respects is a reptile a higher organism than an amphibian? When one animal is said to be higher than another, one of two things may be meant: its structure may be more complicated, as a carved platter is higher than a simple trencher; or its parts may be so arranged as to form a more complicated mechanism. The mere repetition of parts does not raise an animal in the scale; a worm with a hundred segments is no higher than one with ten, any more than a mill with ten pairs of stones is a higher kind of machine than one with a single pair. But if, instead of multiplying the number of millstones, two pairs only were used, one of which was adapted for coarse, the other for fine grinding, a machine of a far higher order would be produced, and it is a similar differentiation of parts for special uses and co-adaptation of structures to given purposes which raises an animal above its fellows.

Judged by this standard, a reptile is a decidedly higher animal than an amphibian; its skeleton, for instance, is a better piece of work, the joints being more neatly finished, and the whole mechanism much more perfect.

A third test is based on the facts of development. We saw that a frog, in the course of its development, went through a stage in which it was, to all intents and purposes, a fish, and that it was only after passing through this stage, as well as that of a branchiate amphibian, that it attained its higher adult character. Now the reptile stands in just the same relation to the amphibian, with regard to its development, as the amphibian to the fish. During the earlier stage of its growth it presents certain amphibian characters, such as the presence of gill-clefts; but these lower stages are passed over; the reptile goes beyond the highest amphibian in its development, and is therefore, in this respect also, to be considered as a higher animal.

At the present day there are four types of reptiles: the lizards (*Laartilia*), snakes (*Ophidia*), turtles and tortoises (*Chelonia*), and crocodiles (*Crocodylia*). We will now direct our attention to the first of these groups.

Most existing lizards have four well developed limbs, a long tail, a scaly armour, sometimes supplemented with plates of bone, and teeth, not set in distinct sockets, but firmly fixed to the jaw. The skull is so constructed that the hinder nostrils open far forwards into the mouth. The vertebrae have a peculiar and characteristic form, their articular surfaces being concave in front and convex behind, except in the Geckos or wall-lizards, and that remarkable New Zealand genus *Hatteria* or *Sphenodon*. The heart is composed of three chambers, two auricles and a single ventricle, the latter being again partly divided into two, and thus showing a slight advance on the amphibian heart, in which the ventricle is quite single.

Lizards are very abundant, especially in hot climates;

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most of them are land animals, a few only being inhabitants of fresh water, and one—the genus *Amblyrhynchus* of the Galapagos Archipelago—lives on the sea-shore, and, if hard pressed, takes to the sea.

Through the whole of the Tertiary epoch the lizards are essentially the same as those now existing. Some of the Secondary species, also, have the same characters, but in the chalk are found, in addition, strange marine lizards, such as the genus *Mosasaurus*, which attained a length of 30 feet. As far back as the Purbecks, the lizards have vertebræ like the existing kinds, but on descending to the Solenhofen slates we find abundant remains, which present the lower character of bi-concave vertebræ, and the same is true of all the still older forms, such as the *Telerpeton* of the Triassic sandstones of Elgin and the Permian *Protosaurus*.

Thus the older lizards have a slightly simpler structure than those of the present day, but resemble them, on the whole, so closely, that we must conclude our existing forms to have been derived from the ancient ones, and have no need whatever to assume their special creation. Lizards, then, offer another example of what is meant by a persistent type.

A remarkable instance of this persistence is afforded by a case of quite the same order as that of *Ceratodus*, described in the first lecture. The *Hatteria*, mentioned above, differs from all other lizards in many particulars. Its jaws are armed with a horny beak, and its upper jaw has two rows of teeth, one on the maxillary, the other on the palatine bones; the teeth of the lower jaw bite between these, like a pair of scissors with a double upper blade. The vertebræ are bi-concave, and, along the belly, are placed a number of bony plates.

No other existing form whatever is known presenting these characters, but, about the year 1858, a number of fossils were discovered in the sandstone of Elgin, and amongst them the remains of a large lizard with bi-concave vertebræ, abdominal plates, a horny beak, a double row of upper jaw teeth, and, in fact, altogether like the existing *Hatteria*.

The crocodiles are the only other reptiles the history of which it will be possible to notice in this course. Two of the most important characters by which they are distinguished from lizards are, the lodgment of the teeth in distinct sockets and the position of the hinder nostrils or posterior nares. The maxillary, palatine, and pterygoid bones are so disposed as to form a remarkable shelf or partition in the roof of the mouth, thus bringing the posterior nares to the hindermost part of the throat. The soft palate forms a veil in front of these apertures, and hangs down so as to rest on the back part of the rudimentary tongue, and thus, except when the animal is swallowing, entirely shuts off the cavity of the mouth from the air passages. This arrangement has been prettily explained by the crocodile's habit of killing its prey by drowning; it is said that it can hold a captured animal under water, while its own nostrils—placed at the end of the long snout—are just above the surface, and thus is enabled to breathe freely, the air passing through the posterior nares, behind the veil of the palate, and so to the lungs, while its prey is being suffocated. This is an admirable explanation as far as the crocodile is concerned, but, unfortunately, it is probably untrue, for precisely the same arrangement is found in the Gavial and other crocodilians which live upon fish.

(To be continued.)

PHYSICAL SCIENCE IN SCHOOLS

PROF. ROSCOE has taken the right view when he says that science teaching in schools will remain unsatisfactory as long as it does not receive the same range and time as the subjects which at the present time

preponderate so greatly. Granting the necessity of devoting more time to science, it follows, almost as a matter of course, that science teaching ought to begin at an earlier age than now. For else, where is the time to come from? The other alternative—to add a couple of years to the time required to pass through the present curriculum of a public school—would be accepted by very few parents. But there is no need for this alternative. The teaching of the elements of physical and chemical knowledge is most beneficially begun in early years. Some of the foremost thinkers of the scientific world assert and support this view, as may be gathered, for instance, from the Sixth Report of the Royal Commission on Science Teaching. I would mention, in addition to this, that Liebig strenuously advocated ("Chemische Briefe," Leipz. und Heidelb., 1865, 50th letter) the teaching of such elementary chemistry in *village schools* as bears upon the constitution of air, water, the ash of plants, and explains the process of combustion. The great German philosopher would hardly have done so, without being sure that the pupils will profit by the teaching. The average age of such a pupil is, I believe, twelve years, and he receives, as far as I am aware, no preparatory instruction in algebra or geometry.

It is surprising to find a man of the educational eminence of Mr. Wilson battling against early science teaching. I am inclined to ascribe his opinion on this matter to an incomplete view taken by him of the true significance science teaching has. Mr. Wilson considers the study of physical science as a means of developing merely the reasoning faculty of a boy, leaving out of sight the equally important function of calling forth and sharpening the faculty of *observation*. As for reasoning alone, certainly, the languages, and still more, mathematics, afford at least an equally good basis. It is just the circumstance that a sound teaching of science shows to the young mind the difference between evidence as resting (wholly, or to the greatest extent) on the *teacher's statement*, and evidence based on *facts put actually before the pupil*, which makes the study of science so valuable from a general educational point of view.

Early beginning of science teaching suggests itself for yet another reason. Everyone, with but the least experience in educational matters, knows that in order to be successful in instruction, one must repeatedly go over the same ground during the curriculum of a boy's education, and gradually expand the subject in the repetition. Why, then, shall not science, if it is to enter organically into the education of a boy, and not be merely tacked on to him, receive the same treatment? Let a boy at the age of ten or eleven begin with witnessing all the experiments which are usually performed in illustrating those sections of Chemistry and the science of Heat, that are required from the candidates of the London University Matriculation Examination. Let the boy become thoroughly acquainted with the *facts*, and let at this time as little theory be placed before him as possible. After such a course, which might be made to fill up two years, there should be a pause in the study of these branches of science for a year, or even two, before allowing the pupil to resume the same in a fuller and more theoretical way. The hours gained might be given to mathematics. Of course it would be out of place to give here anything like a programme of how the above idea should be realised; I must just content myself with throwing out the hint. After the initiatory course the pupil will be in better condition to follow later the theoretical parts than he is under the present system, where he has to overcome simultaneously the novelty of the facts and the difficulties of the theory.

Science acquired in this way will be very different from that which is hastily got up in the last six or eight months of a boy's stay in the school, and mostly, too, under the pressure and anxiety which accompany the preparation for some examination, say the London University Matriculation.